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Cartilage strains during insertion of osteochondral grafts and their relationship to chondrocyte viability

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Purpose: Osteochondral grafting procedures are routinely used to replace articular cartilage lesions with true hyaline tissue. However, it has been shown that high insertional forces affect the cell viability of the graft, particularly in the superficial zone. In this study we investigated the stress-strain response of cartilage plugs during impaction.

Methods and Materials: Fresh bovine osteochondral plugs were harvested from 22-26 week old animals. Based on a previous field study, the plugs were impacted at 300N load and 100mm/s velocity using a clinical tapping device. High speed videos were utilized to study the deformation of the osteochondral plugs during impaction at a resolution of 1024x1024 pixels and 2000 frames-per-second. Every plug was impacted multiple times, while the load was recorded. Comparing the digitally stored grayscale images, axial and radial displacement fields were determined with two-dimensional correlation analysis software. The strains of the superficial, middle and deep cartilage layers were then calculated. Using Live/Dead cell assays, tissue samples were analyzed for cell viability.

Results: The highest amount of cell death was seen in the superficial layer, while the lowest cell death occurred in the deep cartilage layer. Strain values showed a distinct non-linear behavior with the highest radial strain levels in the superficial layer. Often, radial strains of 10 to 15% were reached. Axial strain showed more evenly distributed character throughout layers with values around 10%.

Conclusions: The witnessed superficial radial strains appear high, since only 2-5% are expected under physiological conditions. Therefore, radial deformation during impaction may play a causative role for chondrocyte death.

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MRI and clinical evaluation of patella resurfacing with press-Fit osteochondral autograft plugs

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Purpose: The purpose of the present study is to prospectively analyze the clinical outcome and the MRI appearance of patients treated using autologous osteochondral transfer for the repair of isolated symptomatic full-thickness cartilage lesions of the patella.

Methods and Materials: Functional outcome scores were collected before surgery and at most recent follow-up using IKDC, SF-36, and ADL. All MR studies were scored according a previously described cartilage repair criteria.

Results: From September 2002 to July 2006, 22 patients with a mean follow-up of 28.7 months underwent patella osteochondral autograft. There was a significant improvement in all outcome scores. The mean post-operative IKDC score was 74.4 ± 12.3 ($P = 0.028$). The mean ADL score was 84.7 ± 8.3 after surgery ($P = 0.022$). The mean SF-36 improved to 79.4 ± 15.4 at follow-up ($P = 0.059$). In all 14 patients, there was a "step off" at the subchondral plate and tidemark of the osteochondral plug, relative to the adjacent native patella. The plug morphology was flush in 10 patients and proud in four patients relative to the adjacent cartilage. Percentage fill by repair cartilage was 67-100% in all cases. All patients had evidence of fissure between the donor-host cartilage interface. There was complete trabecular incorporation of the osteochondral plug in 67% of cases.

Conclusions: Patella autologous osteochondral transplantation is an effective treatment for focal patella chondral lesions with significant improvement in clinical follow-up. The osseous component of the osteochondral plug appears to heal predictably but the interface between the plug and host cartilage does not completely integrate.

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Cellular repopulation of allografts: current insights

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Purpose: We have investigated the DNA fingerprint profile of 42 viable meniscus allograft biopsies. Additionally a limited number of transplanted deep frozen and viable allograft specimen were examined histologically to visualize cellular repopulation.

Methods and Materials: 42 biopsies of a viable meniscal allograft were analyzed using DNA fingerprint technology. The DNA fingerprint profiles of the biopsies were divided into 5 categories (ranging from complete donor DNA (1) to complete acceptor DNA (5)). Basic histology was performed on a limited number of specimen to determine the morphology and the cellularity of the superficial and deep zone of the allograft.

Results: 28 biopsies had complete acceptor DNA (5); 8 biopsies more acceptor than donor DNA (4), 3 biopsies had as much donor as acceptor DNA (3), 1 biopsy had more donor than acceptor DNA (2) and 2 biopsies had only donor DNA (1). Specimen obtained after viable meniscal allograft transplantation showed a normal cellularity in the deeper areas of the graft while deep frozen specimen were hypocellular.

Conclusions: Our data show that donor cells are able to survive in a human viable transplanted meniscus for a long period. The authors hypothesize that the cellular repopulation process by acceptor cells is more incomplete and slower in the human model in contrast to the animal model where repopulation is forthwith. These data invite for a re-appraisal of the discussion on the use of viable vs. deepfrozen allografts and support further research into repopulation biology of allografts and scaffolds.

22.3

Matrix-induced Autologous Chondrocyte Implantation (MACI®): Biological and Histological Assessment.

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Purpose: Matrix-induced autologous chondrocyte implantation (MACI®) has been a treatment of cartilage injury since 2000, but little is known of the histological paradigm of tissue regeneration after implantation. MACI® is a stable cell-based delivery system that enables the regeneration of hyaline-like cartilage.

Methods and Materials: From a cohort of 56 MACI® patients, we examined the phenotype of chondrocytes seeded on type I/III collagen scaffold, and conducted progressive histologic assessment over a period of six months.

Results: Chondrocyte-seeded collagen scaffolds from patient implants were analyzed by electron microscopy, immunohistochemistry (type II collagen and S-100), and reverse transcription polymerase chain reaction (aggrecan and type II collagen). Coincidental cartilage biopsies were obtained at 48 hours, 21 days, 6 months, 8 months, 12 months, 18 months, and 24 months. Our data showed that chondrocytes on the collagen scaffold appeared spherical, well integrated into the matrix, and maintained the chondrocyte phenotype as evidenced by aggrecan, type II collagen, and S-100 expression. Progressive histologic evaluation of the biopsies showed the formation of cartilage-like tissue as early as 21 days, and 75% hyaline-like cartilage regeneration after 6 months.

Conclusions: This preliminary study has suggested that MACI® may offer an improved alternative to traditional treatments for cartilage injury by regenerating hyaline-like cartilage as early as 6 months after surgery.